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A HUMAN ENGINEERING EVALUATION OF THREE NON-METALLIC COMBAT HELMETS

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ABSTRACT

(R) An evaluation of three conventional combat helmets with chin strap variations was carried out. American, Israeli, and British helmets were evaluated. This technical communication discusses the preliminary field observations recorded by the DCIEM personnel during the field trial. It precedes analysis of both the questionnaire results or the range scores of the individual soldiers. At this preliminary stage in the evaluation, it would appear that a hybrid of the existing Israeli helmet with a revised American internal suspension, and an amended British three point chin strap direct snap quick release feature would most effectively meet the requirements of the CF.

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1.0 INTRODUCTION

(U) The Canadian Forces (CF) presently use the M1 combat helmet. While infantry small arms ballistic projectile material strength, shape, and muzzle velocity have been vastly improved over the years, the M1 helmet has been virtually unchanged since World War II. The M1 provides very little protection to infantry rifle fire (ballistic protection - 1400 ft/sec).

(U) The Directorate of Clothing, General Engineering and Maintenance (DCGEM) is currently evaluating several different types of infantry helmets, with a view to replacing the M1 helmet. DCGEM requested that DCIEM provide human factors support during a field trial of three foreign helmets.

(U) If presently available body armor had been worn at all times in Vietnam, casualties could have been reduced by 40% (1). The major factor that inhibits the proper wearing of protective materials is 'user acceptance'. It is for this reason that human factors can play a very important role in the selection of both body armor and protective helmets.

(R) The trend in conventional head protection for the infantry soldier has been to provide increased ballistic protection with a reduced weight helmet (2). Because weight has always been directly related to ballistic protection, reduced weight while maintaining ballistic protection has been impossible to achieve without developing a new material. Recent technological advances in plastics, such as Kevlar and nylon, have made the achievement of these two criteria possible, albeit with marginal improvement in effect.

(R) In the reported field trial, the non-metallic helmets of three countries (United States, Israel, Britain) were evaluated from a human engineering point of view. The Israeli and American helmets*, which are made of different numbers of layers of Kevlar, have been used in action in Lebanon and Grenada (U.S. 82nd Airborne Division) respectively. The British helmet** has seen extensive use in Northern Ireland.

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(R) * The American and Israeli Kevlar helmets are made of a high strength laminate with a material strength which compares to that of steel, but which kilogram for kilogram has better ballistic protection than steel. The American Kevlar helmet, with a 0.5 inch standoff, has impact protection of 2000 ft/sec from an American anti-personnel projectile.

(R) ** The shell of the British helmet is constructed of resin impregnated glass fibre.

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(U) In the development of a new helmet, it is important to consider a large number of human factors criteria, as well as reduced weight and ballistic protection. For example, in normal conditions a portion of perceived helmet weight can be attributed to inertial forces, momentum, and helmet standoff (1). Criteria considered important to the design of a helmet are:

a) Adequate head standoff;
b) Comfortable suspension;
c) Stability during running, jumping, descending, climbing, crawling, marching, firing weapons;
d) Nuclear Biological and Chemical Warfare (NBCW) respirator compatibility;
e) Appearance;
f) Uninhibited visibility while wearing helmet;
g) Communications gear compatibility;
h) Use with cold weather cap;
i) Use with hearing protectors;
j) Compatibility with the sights on various weapons;
k) Adequate sizes to accommodate the soldier population; and
l) Use in confined quarters such as in Armored Personnel Carriers, Tanks, and Troop carrying helicopters (3).

(R) Because of time and material constraints, not all of these criteria were evaluated during the field trial. It was the opinion of DCGEM personnel that, with proper initial adjustment of the internal suspension, helmet stability was inherently controlled by the chin strap. For this reason, DCGEM decided that the helmets should be evaluated, for the above mentioned criteria, with different chin straps. Separately, an evaluation of four different fragmentation jackets, as well as the new 82 type webbing, was performed at the time of the helmet trial.

1.1 Background to the Field Trial

(U) The design and development of the combat helmet is organized under the following workplan:

Phase I (Jan 84 - Oct 84) Examination of foreign helmets for deficiencies in the area of comfort, acceptability, and equipment compatibility.

Phase II (Nov 84 - Mar 85) Development in conjunction with industry, an advanced development model based on design criteria established during Phase I and including further evaluation.

Phase III (Apr 85 - Sep 85) Production of engineering developmental models in two size ranges and in three models for user evaluation.

Phase IV (Nov 85 - Mar 86) User and ballistic trials and establishment of

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final modifications.

Phase V (Apr 86 - Sep 86) Production of final engineering development models incorporating the latest acceptable protective materials and modifications (4).

This Technical Communication deals with work carried out with respect to Phase I.

1.2 Purpose

(R) The aim of the field trial was to obtain precise information under controlled conditions so that the design authority could contract to Canadian industry for the development of a prototype Canadian helmet (5). DCIEM was approached to provide qualified human engineers to assist in administering the helmet questionnaire, as well as to comment on any limitations to the field trial (Appendix 1). During the helmet trial DCGEM evaluated fragmentation jackets and 82 pattern field webbing. The webbing was worn frequently through the trial. The various helmet combinations and fragmentation jackets used are listed in Table 1.

(R) Table 1. Equipment Evaluated on the Field Trial

Helmets

A. U.S. Helmet with Israeli Chin Strap
B. Standard U.S. Helmet
C. Israeli Helmet with U.S. Chin Strap
D. Standard Israeli Helmet
E. Standard British Helmet

Fragmentation Jackets

A. Israeli with built-in Webbing
B. Standard Israeli
C. Standard American
D. Prototype Canadian

2.0 PROCEDURE

(U) The trial was carried out at Heals Range in Saanich County on Vancouver Island during the period of Oct. 1-12, 1984. Twenty members of 3 PPCLI (3rd Battalion Princess Patricia's Canadian Light Infantry) participated in the field trials. Each soldier was given a helmet for a 1.5 day evaluation period, after which he was issued with another helmet for evaluation. Each period

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consisted of:

1. Obstacle course physical training (Appendix 2);
2. Section field craft (Appendix 3);
3. Weapon training (Appendix 4);
4. Digging;
5. NBCW training (Appendix 5);
6. Range firing (Appendix 6); and
7. Questionnaire evaluation (Appendix 7).

3.0 OBSERVATIONS

(U) During the 1.5 day period, the helmet features listed in Table 2 were considered when evaluating each helmet for fit, stability, visibility, NBCW interface, weapons compatibility, and soldier subjective opinion. Along with this, the soldiers' key head measurements were taken to provide information on the soldier sample (Appendix 8). The head measurements will be useful during Phase III of the helmet tasking (Sec. 1.1) to verify whether the helmet sizes produced are representative of the user population.

(U) Table 2. Helmet Features

	American (Helmet B)	Israeli (Helmet D)	British (Helmet E)
Material	Kevlar	Kevlar	Nylon
Int. Suspension	6-point	6-point	4-pt with browpad
Headband	leather band	leather band	standoff padding
Chin Strap	2-point	3-point	3-point
Quick Release	snap	-------	ring and snap
Chin Cup	open	covered	covered
Rain Ledge	yes	no	no

3.1 Fit

(R) The American helmet was supplied in three sizes. (There is also a fourth small size to fit females with small heads which was not available at the field trial.) The internal suspension and head band were found to be very simple to adjust. Two sizes of Israeli helmet were provided for the field trial; medium and large. A major drawback with the Israeli helmet was that each internal suspension strap had to be adjusted individually. This made the helmet very tedious to modify in the field. Although only one size (medium) of the British helmet was provided for the field trial, it is actually produced in three sizes (6). It was found that adjustment was easily made to the British browpad, which provided a close fit over a number of head sizes. The browpad was cut away around the ears to accommodate custom-made hearing protectors.

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(R) The troops were instructed to fit the helmets themselves for personal comfort. Unfortunately, they were not familiar with the internal suspensions of the Israeli and American helmets. This resulted in a large number of soldiers having improper helmet fits at an early stage in the trial, which may have affected the reliability placed on responses concerning 'helmet fit' in the questionnaire (7). This was changed after the first 1.5 day period with a brief field description on the method of adjustment of each helmet by an NCO before it was used.

3.2 Stability

(U) Helmet instability can cause a shift in the centre of gravity of the helmet towards one side of the head. Soldiers are aware of asymmetrical loading as small as 1/4 lb (1).

(R) The American helmet needed continual adjustment during the obstacle course (Appendix 2), and during weapons firing (Appendix 4). For a given helmet, the three point chin strap provided more helmet stability than the two point system. For this reason an Israeli three point chin strap was introduced to increase the stability of the American helmet. Unfortunately, because of this amendment the helmet could not be effectively used when firing the Carl Gustav (Sec. 3.5.4) or the TOW Missile (Sec. 3.5.7). It was observed that the combination of an Israeli three point chin strap and six point internal suspension, provided the greatest stability. It was also noted, however, that some of the Israeli helmets had internal suspension intersection points which were off the center of gravity of the helmet. This may have caused the soldiers to perceive the helmets as being heavier than they actually were. The British helmet, with its padded internal suspension, was rated as fairly stable.

(R) It also became apparent early in the trial that the stability introduced by the three point chin strap posed an impediment to rapid donning and doffing of the respirator during NBCW drills (Sec. 3.4).

3.3 Visibility

(R) Good visibility at all times is of the utmost importance to the infantryman. Users of each helmet were observed during low crawl; prone, sitting, kneeling, and standing position firing; and various field craft evolutions (Appendix 3). There was a general consensus among the soldiers that visibility was less restricted with the Israeli and British helmets than with the American helmet. In fact, the American helmet covers 11% more of the soldiers head than the M1 helmet (8). The main hindrance to visibility occurs above the Line of Sight (LOS) because of the protruding rain ledge on the front. This problem is discussed in more detail in Sec. 3.5.5 where weapons firing in the prone position is examined.

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3.4 NBCW Interface

(U) A helmet which can be removed and put on quickly, as well as provide comfort if worn over a respirator for long periods of time, is very desirable for the infantry soldier. Unfortunately, the length of the trial precluded observations of pressure points between the internal suspension and respirator straps, or the effect of long term heating of the head. The analysis was mainly directed towards rapid donning and doffing of the respirator. There are standard drills which are performed by soldiers in the case of gas attack (see Appendix 5). The CF specifies 12 seconds as the maximum time to put on a respirator and refasten the helmet.

(R) The American two point chin strap and six point internal suspension posed no inconveniences to rapid donning of the respirator. Although the Israeli internal suspension posed no problems either, the three point chin strap was very difficult to rapidly unfasten and fasten. The chin strap also fastened over the respirator canister which resulted in an additional hindrance. The British three point chin strap incorporated a quick release feature, which made it usable with the NBCW respirator. It might be more appropriate, however, to change the quick release feature from a ring and snap to a direct snap. A direct snap is presently used on the M1 helmet, and there have been no reported problems with accidental disconnection. Because the British helmet uses a pad to maintain head standoff, the added mass of the respirator on the head may cause the helmet to feel very tight. It was noted during the trial that the men were sweating quite a bit with the British helmet.

(R) In addition to the standard gas drills, a trial was conducted in which a soldier had to put on his own gas mask and then help out another soldier who had already succumbed to a gas. It was noted that, after the soldier donned his own respirator, the standard American helmet was very easy to remove and put on another fallen soldier. Because there was no quick release feature on the Israeli helmet, it provided a great hindrance to the rescuer.

3.5 Weapons Compatibility

(U) Each helmet and chin strap combination was evaluated with a number of standard infantry weapons. These included the:

a) FNC1 Rifle;
b) M72;
c) Carl Gustav;
d) 81 mm Mortar;
e) GPMG;
f) 50 Cal. Machine Gun;
g) M60 Grenade; and
h) TOW Missile.

Compatibility with each of these weapons is analyzed in the following sections.

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3.5.1 FNC1 Compatibility

(R) Under normal firing conditions, the FNC1 standard NATO rifle must be cheeked (the weapon must be firmly placed against the cheek) for proper sighting. Because of the larger size and greater lateral dimension of the American helmet on narrow headed soldiers, cheeking the rifle was very difficult with a stable three point Israeli chin strap. The American helmet was designed to allow a rifle to be cheeked when in the prone position with the existing two point chin strap. No sighting problems were introduced by the Israeli and British helmets. One drawback with the Israeli helmet, however, was that the metal chin strap buckle irritated the soldier's cheek bone when the rifle was cheeked.

3.5.2 81 mm Mortar

(R) It was almost impossible to sight this weapon properly with the American helmet. As noted by the troops, the rain ledge on the front end of the American helmet inhibited sighting of the weapon. The Israeli helmet added no apparent problems to the sighting of this weapon. The British helmet was not evaluated (Appendix 1).

3.5.3 M72 Anti Tank Weapon

(R) It was noted that because of the high sight on this weapon, none of the helmets disrupted proper sighting or firing.

3.5.4 Carl Gustav

(R) Because the sight on the Carl Gustav is so close to the barrel, any excessive helmet breadth causes a sighting problem. As noted previously, the American helmet posed the greatest sighting impediment of the three helmets evaluated. Range scores were kept for American and Israeli helmet soldier pairs with this helmet when it was fired live with a subcaliber insert. These will be analyzed by DCGEM in a future report. The British helmet was not evaluated during firing (Appendix 1).

3.5.5 GPMG, 50 Cal. Machine Gun

(R) It is important to note that 60% of the existing M1 helmets make contact with the back of the neck when a soldier is in the prone position (2). This contact usually resulted in the helmet's being pushed over the eyes. The rear of the American and Israeli helmets have been cut away to prevent contact with the fragmentation jacket collar when in the prone position.

(R) The GPMG and 50 Cal. Machine Gun were only fired from the prone position during the trial. A drawback of the American helmet, as discussed in Sec. 3.3, was that visibility in the vertical plane was decreased slightly by the rain ledge. This required that the soldier accommodate by tilting his head (and tensing the muscles in the back of his neck) more than the soldier with the British or Israeli helmet. The British and Israeli helmets posed no problems to the sighting or firing of these weapons.

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3.5.6 M60 Grenade

(R) The grenade throwing drills provided a means by which the helmets could be evaluated during low crawl and throwing. Visibility and stability were the two main criteria of interest observed. During throwing drills, the helmets were notably less stable with the two point chin strap than with the three point system. For this reason, the Israeli and British helmets were more acceptable than the American helmet (see Table 2). The comments on visibility during low crawl are similar to those discussed in Sec. 3.5.5 with regard to firing a weapon in the prone position.

3.5.7 TOW Missile

(R) In order to guide the TOW (Tube launched Optical controlled Wire guided) missile, a soldier must track the target in his sight until the missile reaches the target. Although this weapon was not observed on the helmet trial, it was noted by some of the senior NCO's that aiming and firing the TOW would be a problem with the American helmet.

3.6 Soldiers' Opinions

(U) Subjective evaluations are important to determine how the combat soldier feels about his equipment. For this reason, oral comments were encouraged from the troops throughout the trials and were duly noted, where applicable. (The only exception to this was during the actual filling of the questionnaire when talking was discouraged except for explanatory questions.)

(R) Subjectively, the men felt that the light green Kevlar helmet shell (American, Israeli) provided more protection than the dark green Nylon helmet shell (British). It was also ascertained that the men felt that NBCW protection and visibility were the two most important features of helmets. During the first day of the field trials, some negative feeling was generated by the American helmet when it was observed that it resembled an old German World War II helmet. After several days of obstacle work, field craft, and weapons training, it was apparent that the men favored the Israeli helmet. They agreed that they would be much more comfortable as soldiers with the Israeli helmets, as long as something was done about the problem of using a three point chin strap without a quick release feature. Several of the men commented that a hybrid, which consisted of an Israeli helmet with a British three point chin strap (without the British chin cup), would satisfy all of the requirements of an acceptable helmet.

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4.0 DISCUSSION

(U) This report is intended only to document DCIEM human engineering observations made during the field trials. A subsequent report will be produced by DCGEM which will encompass a statistical analysis of the questionnaire presented to the troops (Appendix 7). During the trial itself, a number of field evolutions with each individual helmet were observed. This provided the ability to observe adjustment of the helmet in the field to accommodate for the requirements of certain activities (Appendix 3).

(R) Each of the helmets was observed by human engineering personnel for 1.5 days. From strictly an observational point of view, the Israeli and British helmets were the most acceptable in terms of weapons compatibility, stability, and visibility. The American helmet, on the other hand, demonstrated the best respirator interface.

(R) Unfortunately, as far as the troops were concerned, the American helmet entered the trial with a negative connotation with the past. Although the long term effects of wearing any of the helmets was not measured, it is quite possible that long term usage of the British helmet may cause heating problems as well as possibly skin irritations.

5.0 CONCLUSIONS

(R) Although the conclusions of the trial will not be complete until the questionnaire responses are evaluated at DCGEM, some general human engineering observations are:

American Helmet

1. Good NBCW respirator interface with two point chin strap (Sec. 3.4),
2. Good all around head protection (Sec. 3.3),
3. Helmet easily adjusted (Sec. 3.1),
4. Negative opinions with respect to helmet shape (Sec. 3.6),
5. Visual restriction during weapon sighting and low crawl conditions (Sec. 3.5.6),
6. Excessive helmet breadth on narrow heads (Sec. 3.5.1)
7. Poor stability with the two point chin strap (Sec. 3.2),
8. Sighting problems with some weapons (Sec. 3.5.2, 3.5.4, 3.5.5, 3.5.7);

Israeli Helmet

1. Good visibility in vertical plane, no added problems during sighting (Sec. 3.3),
2. Good stability with the three point chin strap (Sec. 3.2),
3. Poor NBCW interface with standard three point chin strap (Sec. 3.4),
4. Some irritation of the cheek with helmet chin strap buckle (Sec. 3.5.1),

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5. 6-point internal suspension adjustment very tedious (Sec. 3.1);

British Helmet

1. Good visibility in vertical plane, no added problems during sighting (Sec. 3.3),
2. Good interface with British hearing protectors (Sec. 3.1),
3. Head band adjustment quite simple (Sec. 3.1),
4. Helmet not compatible with respirator (Sec. 3.4),
5. Headband and browpad cause sweating, may cause head irritations (Sec. 3.4), and
6. Subjectively the dark green helmet shell does not appear to be as ballistically strong as the light green Israeli and American helmets (Sec. 3.6).

(R) At this preliminary stage in the evaluation, it would appear that a hybrid of the existing Israeli helmet with a revised American internal suspension, and an amended British three-point chin strap with a direct-snap quick-release feature will meet CF requirements.

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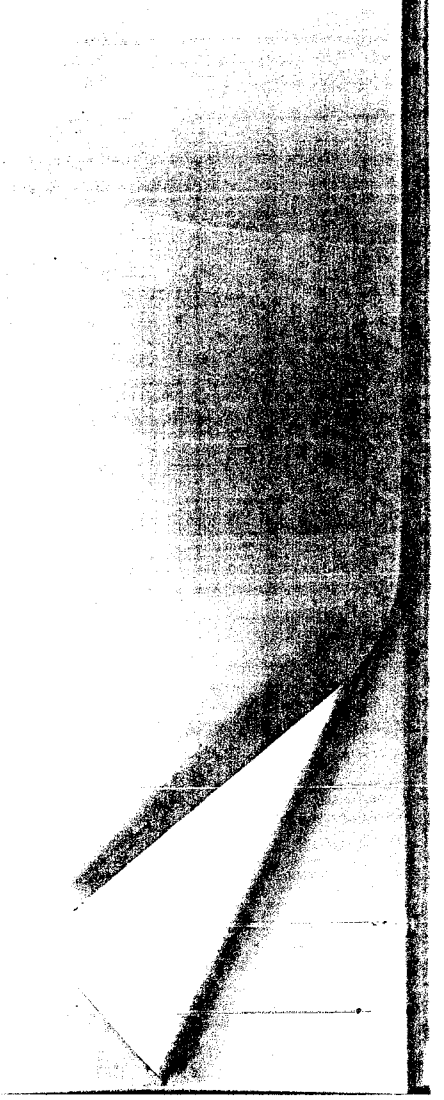

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APPENDIX 1

(R) Limitations of the Field Trial

1. The helmets (American, Israeli, British) were evaluated against each other and not against the existing M1. Because a 'control' was not used, the best attributes of the individual helmets may not be better than that of the M1.

2. A uniform and balanced systematic testing order was not stringently followed for the helmet trial. This resulted in some of the soldiers evaluating the same helmet twice. There was no testing order for the fragmentation jackets. This may affect the results of the questionnaire survey.

3. The trial procedure was not thoroughly followed for each helmet. (The British helmet was not worn during any range firing.)

4. The British helmet arrived for only the last day of the trial, and the various fragmentation jackets arrived after the trial had started.

5. No formal meetings took place between the different trial evaluators to discuss stringent trial procedures; the testing order implementation was delegated to junior officers in the PPCLI.

6. The troops were not briefed on how to adjust their helmets when they were put on initially. This may have compromised the questionnaire question on stability.

7. There is no way to be sure that the men fired their best on the range with the helmets that they disliked, when they knew that their range scores where being retained for future analysis.

8. The ballistic test, which 'completely distroyed' the British helmet, was done before the helmet had been evaluated on the questionnaire. The soldiers' attitudes changed significantly when they noticed that the American helmet, which they had previously evaluated and disliked, appeared to be far more ballistically protective than the British helmet.

9. Towards the end of the two week trial the face validity, which is defined as the extent to which a test condition matches or reproduces conditions in the real world (2), was not present. The last helmet, which was the British one, was not rigorously evaluated.

10. The fragmentation jacket questionnaire, which was prepared elsewhere, was long, confusing, ambiguous, had essay style questions, and required information which was not available to the troops. There is a need to develop questionnaires for soldiers which are short, easy to understand, and which require little effort to administer or complete.

11. The helmets were not tested for:

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a) Parachuting: The American helmet is supposed to be designed for this activity in particular.

b) Wearing With a Cold Weather Cap: In our Canadian climate this is a very important factor. It is suspected that the British helmet cannot accommodate a cold weather cap.

c) Use With Communications Gear: The American helmet is also supposed to have been designed for this purpose.

12. Some of the Israeli helmets had intersecting internal suspension straps which were off the centre of gravity of the helmet. Without proper adjustment, the helmet weight may have been perceived as being more than it actually was.

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APPENDIX 2

(U) Obstacle Course Physical Training

The obstacle course was completed by each soldier for every helmet. The course, which was physically demanding, was intended to permit the soldiers to evaluate the helmets for stability, comfort, adjustability, and fit for a number of physical activities (jumping, climbing, running, low crawl). The obstacle course consisted of:

1. Climb and descend a 25 ft high rope net obstacle and run 25 ft;
2. Crawl 24 ft under 2 ft high and 3 ft wide barbed wire and run 50 ft;
3. Run 25 ft up and down an angled log structure with 6 logs per side separated by 3 ft each and run 50 ft;
4. Hop across the tops of six log ends of different elevations, spaced 3 ft apart, and run 100 ft;
5. Jump over three walls of heights 2 ft, 4 ft, and 6 ft, spaced 25 ft apart and run 50 ft;
6. Run 50 ft on 4 in thick board jumping down 6 ft at the end, and run 50 ft;
7. Walk 100 ft along loosely attached suspended logs in 25 ft sections, aided by an overhead rope, and run 50 ft;
8. Run up a ladder angled at 45 degrees to 6 ft of height, run across 25 ft of 4 in board, jump down, and run 150 ft;
9. Swing 100 ft on 2 in thick rope over an 8 ft deep pit, and run 50 ft;
10. Climb over a 12 ft wall with the aid of a 1.5 in rope, and run 50 ft;
11. Run 150 ft across an elevated hammock type bridge, run 50 ft; and
12. Climb an 8 ft wall, and run 150 ft to the finish.

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APPENDIX 3

(R) Section Field Craft

One of the limiting factors in the appreciation of the attributes of one helmet over the others is combat effectiveness. This factor is a function of how the soldier feels about his helmet in the combat field. The section field craft segment of the field trial allowed the soldiers to get simulated combat experience with their trial helmets. A number of combat routines were performed which included:

a) Camouflage drills;
b) Patrolling;
c) Bush clearing;
d) Tree line clearing; and
e) Rapid disembarkment from an AVGP (Armoured Vehicle General Purpose).

These field craft drills were useful in providing information on helmet fit, stability, and comfort. Along with this, the simulated combat experience allowed the soldiers to get a subjective feeling about the protective value of each helmet.

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APPENDIX 4

(R) Weapons Training

The weapons training drills were performed mainly to see if the soldiers could sight and handle the weapons that they would be exposed to in wartime, with each trial helmet. Because of safety considerations, only the FNC1, the FNC3, and the Carl Gustav with a subcaliber insert, could be fired at Heals range. All larger guns, anti-tank weapons, and grenades were not fired with live ammunition. The firing procedures, and how they were influenced by the various helmet combinations, were analysed individually in Sec. 3.5. The weapons drills were performed with a rigid, time dependent procedure which consisted of:

1. Rapid assembly, sighting, and firing (blank rounds) of the GPMG, and 50 Cal. Machine Gun;

2. Rapid loading and sighting of the M72, and Carl Gustav;

3. Attack drills with mock hand grenades;

4. Aiming and sighting the TOW missile and 81 mm Mortar; and

5. Field evolutions with FNC2 firebase and FNC1 flanking section.

These weapon training drills were performed for the American and Israeli helmet and chin strap combinations during the trial. Because of the late arrival of the British helmet, it was not tested with all weapons.

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APPENDIX 5

(R) NBCW Training

NBCW (Nuclear, Biological, and Chemical Warfare) training is an integral part of the overall training undergone by each Canadian soldier. The CF is presently redesigning the existing respirator to accommodate the soldier population with a better seal and higher protective value.

From an infantyman's point of view, the respirator must be simple, comfortable, effective, wearable with a helmet, and easy to donn. Because of the location of the gas canister on the left side of the mask, a helmet is most easily fastened with a 2-point chin strap. The respirator-helmet interface, however, was analyzed for both two and three point chin straps at the trial. The men were asked to perform the following drill upon hearing the command "gas-gas-gas":

1. Remove helmet;
2. Place respirator on head;
3. Put helmet back on; and
4. Fasten and tighten their chin strap.

This drill was to be performed in under 12 seconds. The standard American Kevlar helmet, with its quick release two point chin strap and six point internal suspension, was satisfactory for use with the respirator. It was noted that the Israeli three point chin strap provided a lot of difficulty for the men because of its lack of a quick release feature. From an NBCW point of view, the Israeli chin strap was clearly unacceptable. The British headband and browpad required additional loosening to obtain a good comfortable fit with the respirator. This was not possible with the time constraints of the "gas-gas-gas" drills. The British three point ring and snap quick release chin strap took too much time to undo. This feature should be changed to a direct snap feature.

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APPENDIX 6

(R) Range Firing

In order to test the helmets for stability during actual firing conditions, the men all fired with each different helmet, except the British one, on the range. The standard procedure was:

1. FNC1 firing from the sitting,
   standing,
   prone,
   kneeling;

2. FNC1 firing during rundown* from four hundred yards; and

3. Carl Gustav firing with a subcalibre insert (7.62 mm) and tracer rounds.

The range scores were retained for each individual soldier as he fired while wearing each helmet. It was hoped to see if the firing accuracy of each soldier was affected by the different helmets and chin straps. A change in accuracy might be due to the ease at which the weapon could be cheeked with each helmet, as well as from the influence of perceived helmet weight (attributable to a shifted centre of gravity) causing fatigue while firing in the prone position. The results of this survey will be reported by DCGEM at a later date.

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* During the rundown drill the soldiers fired from 400 yards, 300 yards, 200 yards, 100 yards, and 50 yards, assuming a number of different firing positions. These included the standing, sitting, kneeling, and prone positions with running in between the firing points.

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APPENDIX 7

(U) NON-METALLIC HELMETS

INDIVIDUAL QUESTIONNAIRE

NAME and RANK _____
DATE _____
GROUP NUMBER _____
CONTROL No OF HELMET _____

1. Did the helmet fit properly? YES NO

Comments? _____

_____

2. Was it easy to adjust the internal suspension?

_____ very easy
_____ easy
_____ acceptable
_____ some difficulty
_____ difficult
_____ very difficult

Comments? _____

_____

3. Did you have difficulty using your rifle while wearing the helmet? YES NO

Comments? _____

_____

4. How comfortable was the helmet?

_____ very comfortable
_____ comfortable
_____ acceptable
_____ slighty uncomfortable
_____ uncomfortable
_____ very uncomfortable

Comments? _____

_____

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5. Did the helmet shift or move about during the trial period? YES NO

Comment? _____

_____

6. Were many adjustments necessary, while in the field, to keep the helmet secure to the head? YES NO

Comments? _____

_____

7. Which helmet by control number do you prefer at this point in the trials? No._____

Any comment? _____

_____

_____

8. Any other comments about the helmet or the trial?

_____

_____

_____

_____

_____

9. Ease of putting on and removing the helmet?

_____ extremely easy
_____ rather easy
_____ only a few problems
_____ had several problems
_____ quite difficult
_____ extremely difficult

Comments? _____

_____

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10. Did the helmet fit properly over your cold weather cap?

_____ Very good fit
_____ Good fit
_____ Had some problems with adjusting the suspension
_____ Very difficult to wear with a cold weather cap

Comments? _____

_____

11. What do you think about the weight of the helmet?

_____ Lighter than my old helmet
_____ Same weight as my old helmet
_____ Slightly heavier than my old helmet
_____ Very heavy

Comments? _____

_____

12. Did the helmet affect your hearing?

_____ Not at all
_____ Slightly
_____ Yes, I feel that my hearing was inhibited

Comments? _____

_____

13. Could the helmet be used with a communications system?

_____ Yes, no problem
_____ Yes, but the helmet had to be adjusted
_____ Not without removing the helmet entirely

Comments? _____

_____

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14. Was the helmet stable on your head during running?

_____ very stable
_____ bounced and moved around a little bit
_____ bounced and moved around a lot
_____ fell off so many times that I had to hold it on

Comments? _____

_____

15. Was the helmet stable on your head while jumping?

_____ very stable
_____ bounced and moved around a little bit
_____ bounced and moved around a lot
_____ fell off so many times that I had to hold it on

Comments? _____

_____

16. Was the helmet stable during grenade throwing?

_____ very stable
_____ bounced and moved around a little bit
_____ bounced and moved around a lot
_____ fell off so many times that I had to hold it on

Comments? _____

_____

17. Was the helmet stable during low crawl?

_____ very stable
_____ bounced and moved around a little bit
_____ bounced and moved around a lot
_____ fell off so many times that I had to hold it on

Comments? _____

_____

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18. What do you think about the location of the chin strap?

_____ Location is alright (fits comfortably)
_____ Too far towards the rear (rubs ear or throat)
_____ Too far towards the front (slides under chin)

Comments? _____

_____.

19. Did the helmet limit your visibility in any direction?

_____ Not at all
_____ Only during certain actions (ie. crawling)
_____ Yes, I had to turn my head quite often to see

Comments? _____

_____

20. When walking through undergrowth, how noisy was your helmet?

_____ Very quiet
_____ Reasonably quiet
_____ Moderately noisy
_____ Very noisy

Comments? _____

_____

21. What is your overall impression of the helmet?

_____ Very good helmet
_____ Good helmet
_____ Slightly better than your old helmet
_____ Not quite as good as your old helmet
_____ I don't like the helmet
_____ Very unsatisfactory helmet

Comments? _____

_____

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APPENDIX 8

(U) Anthropometric Head Measurements

Field Trial - Evaluation of Combat Helmets
Evaluation Location - Esq., B.C.
CF Unit - 3 PPCLI (Infantry)
Human Engineering Scientist - Carl M. Walker
Assisted By - L.H. Johnson (Human Kineticist)

Measurement (cm)

Soldier	Bitragonal-Coronal Arc	Face Length	Head Circumference	Menton-Sellion	Bizygomatic Breadth	Sagittal Arc
Soldier 1	36.5	8.55	56.0	11.5	13.8	37.5
Soldier 2	32.5	8.80	54.0	11.7	13.2	32.5
Soldier 3	37.5	8.60	58.5	11.5	14.4	37.8
Soldier 4	37.5	8.40	57.5	11.9	14.1	36.6
Soldier 5	38.0	9.10	55.5	11.9	13.4	40.5
Soldier 6	37.3	9.00	57.0	11.5	13.9	37.4
Soldier 7	37.8	10.00	57.6	13.3	13.1	39.0
Soldier 8	38.0	9.10	56.0	11.7	12.9	39.3
Soldier 9	36.5	8.10	57.9	11.1	13.9	36.5
Soldier 10	37.8	9.20	58.7	12.0	14.4	35.8
Soldier 11	38.0	9.00	56.2	11.2	13.3	37.2
Soldier 12	36.1	9.20	56.0	11.4	13.9	36.2
Soldier 13	37.3	9.00	58.2	11.6	13.1	37.7
Soldier 14	37.0	9.20	56.2	12.0	13.1	37.9
Soldier 15	38.6	8.80	56.6	11.3	13.2	39.3
Soldier 16	38.3	9.40	56.0	11.8	14.3	36.4
Soldier 17	36.8	9.10	57.5	11.6	13.8	37.1
Soldier 18	38.5	9.50	56.7	12.2	13.4	36.5
Soldier 19	38.2	10.20	58.5	12.6	14.1	38.7